Sony International (Europe) GmbH
S30146US

"Multifunctional linker molecules for tuning electronic charge transport through organic-inorganic composite structures and uses thereof"

CLAIMS

1. A multifunctional linker molecule of the general structure

$$CON_1\text{-}FUNC_1\text{-}X\text{-}FUNC_2\text{-}CON_2$$

in which

X is the central body of the molecule,

$FUNC_1$ and $FUNC_2$ independently of each other are molecular groups introducing a dipole moment and/or capable of forming intermolecular and/or intramolecular hydrogen bonding networks, with the *provisio* that they are not of hydrocarbon nature, and

CON_1 and CON_2 independently of each other are molecular groups binding to functional units comprising metal, alloys of metal, semiconductor or semiconductor core shell materials.

2. A multifunctional linker molecule according to claim 1, in which CON_1 and CON_2 are identical or different and $FUNC_1$ and $FUNC_2$ are identical or different.

3. A multifunctional linker molecule according to claim 1 or 2, characterized in that it exhibits a length between about 8 Å and about 30 Å.

4. A multifunctional linker molecule according to any of claims 1 to 3, characterized in that X comprises a structure having a hydrocarbon skeleton with two identical or different substitu-

ents that are used for connecting to and/or forming of the molecular groups $FUNC_1$ and $FUNC_2$.

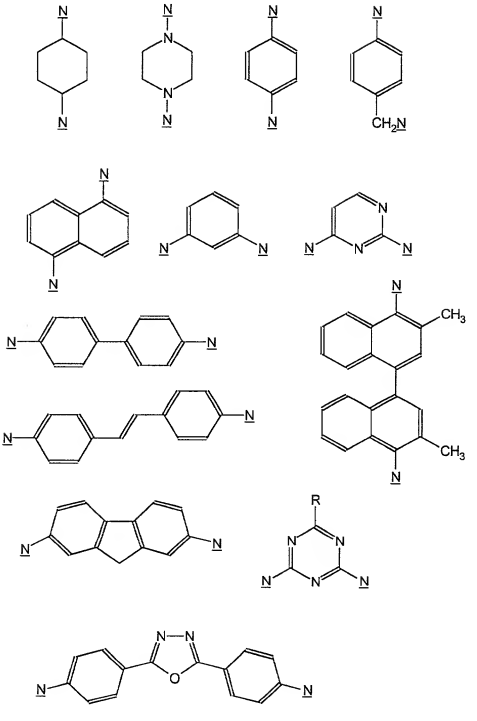
5. A multifunctional linker molecule according to claim 4, characterized in that the substituents of X are selected from the group comprising amines, carboxylic acids, sulfonic acids and phosphonic acids.

6. A multifunctional linker molecule according to claim 4 or 5, characterized in that the substituents of X are directed at an angle α relative to one another such that $90° < \alpha < 270°$.

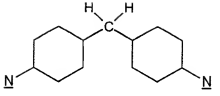
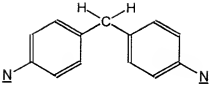
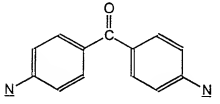
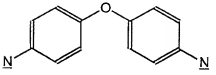
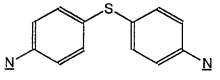
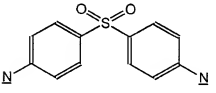
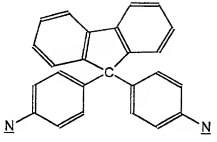
7. A multifunctional linker molecule according to any of claims 4 to 6, characterized in that X comprises a conjugated system, an aromatic π-system
and/or contains heteroatoms, like N, O or S,
and/or contains at least one electron donating substituent, like CH_3, O^-, COO^-, $N(CH_3)_2$ or NH_2, and/or electron accepting substituent, like CN, $COCH_3$, $CONH_2$, CO_2CH_3, $N(CH_3)_3^+$, NO_2, F, Cl, Br, I, OCF_3, or SO_2NH_2.

8. A multifunctional linker molecule according to any of claims 4 to 7, characterized in that X is selected from the group comprising
a) linear or branched structures comprising alkanes, alkenes, alkynes and combinations thereof comprising 3-12 carbon atoms and exhibiting at two ends substituents according to claim 5;

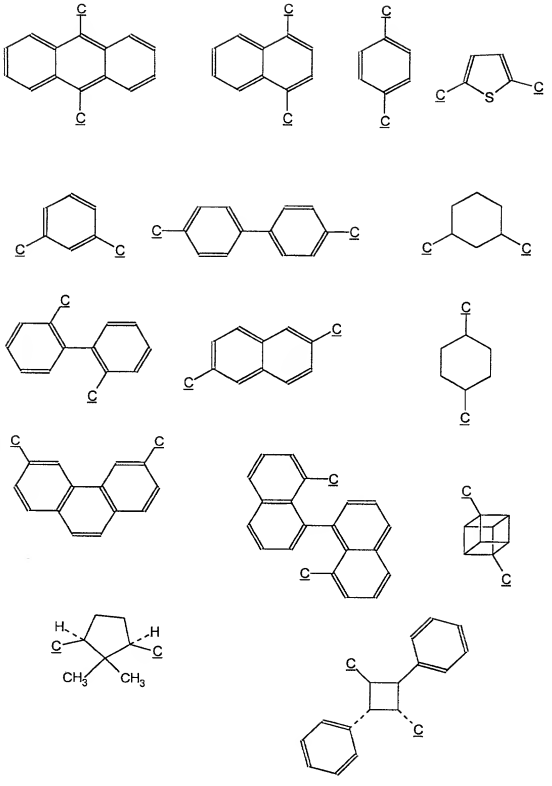
b) structures having the general formula



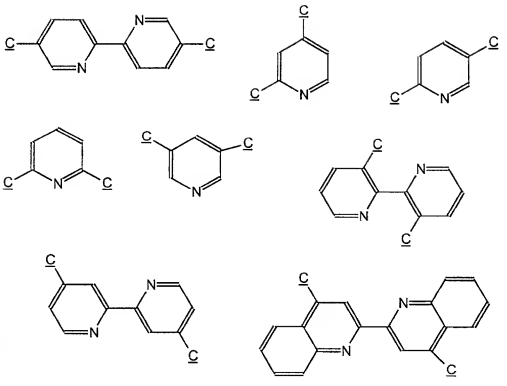
and derivatives thereof containing heteroatoms, like N, S, and/or O, or electron donating or accepting substituents; R can be methyl, phenyl or alkoxyl and wherein $FUNC_1$ and $FUNC_2$ are attached via the N-atoms of the two amine substituents indicated by N; structures having the general formula

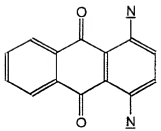
and derivatives thereof containing electron donating or accepting substituents wherein $FUNC_1$ and $FUNC_2$ are attached via the N-atoms of the amine substituents indicated by N; structures having the general formula

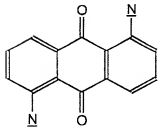


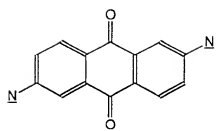
and derivatives thereof containing heteroatoms, like N, S, and/or O, or electron donating or accepting substituents; and wherein $FUNC_1$ and $FUNC_2$ are attached via the carbon atoms of the two carboxylic acid substituents indicated by C; structures having the general formula

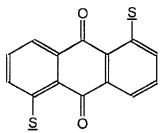


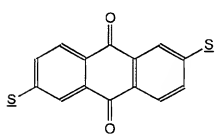
wherein $FUNC_1$ and $FUNC_2$ are attached via the carbon atoms of the two carboxylic acid substituents indicated by C; structures having the general formula



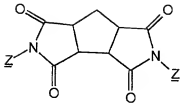


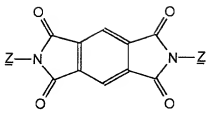


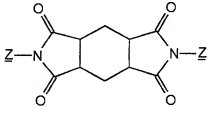


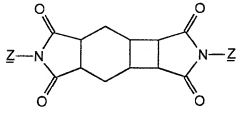


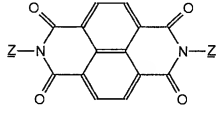
and derivatives thereof containing electron donating or accepting substituents wherein $FUNC_1$ and $FUNC_2$ are attached via the N- or S-atoms of the two amine or sulfonic acid substituents indicated by N and S; structures having the general formula

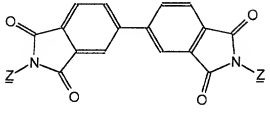


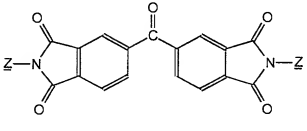


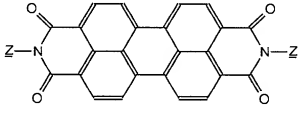












in which Z represents amine (Z = N) or a carboxymethyl (Z = CH(R)C) residue, wherein R is an amino acid side chain and $FUNC_1$ and $FUNC_2$ are attached via Z; and

c) electron donors like hydroquinones and electron acceptors, like quinones and diimides carrying to substituents according to claim 5.

9. A multifunctional linker molecule according to any of claims 1 to 8, characterized in that $FUNC_1$ and $FUNC_2$ independently of each other are connected to X via N, C, S, or P, and are selected from the group comprising

-NH, -NHCO, -NHCONH, -NHCSNH, -NHCONHNH, -NHCSNHNH, -NHCONHNHCO, and –NHCONHNHCO in case of a connection via N;

-CONH, -CONHNH, and –CONHNHCO in case of a connection via C;

$-SO_2NH$, $-SO_2NHNH$, and $-SO_2NHNHCO$ in case of a connection via S; and

$-PO_2NH$, $-PO_2NHNH$, and $-PO_2NHNHCO$ in case of a connection via P.

10. A multifunctional linker molecule according to any of claims 1 to 9, characterized in that CON_1 and CON_2 connected to $FUNC_1$ and $FUNC_2$ via NH or CO, independently of each other are selected from the groups comprising

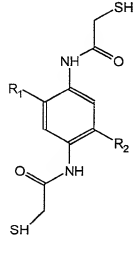
$-(CHR)_nCOOH$; $-(CHR)_nNC$; $-(CHR)_nNH_2$; $-(CHR)_nNHCS_2H$; $-(CHR)_nOPO_3H_2$; $-(CHR)_nOSO_3H$; $-(CHR)_nPO_3H_2$; $-(CHR)_nSH$; $-(CHR)_nSO_3H$; –CSOH; and $-CS_2H$ in case of a connection via NH; and

$-(CHR)_nCOOH$; $-(CHR)_nNC$; $-(CHR)_nNH_2$; $-(CHR)_nNHCS_2H$; $-(CHR)_nOPO_3H_2$; $-(CHR)_nOSO_3H$; $-(CHR)_nPO_3H_2$; $-(CHR)_nSH$; and $-(CHR)_nSO_3H$ in case of a connection via CO; and

where R is H, CH_2OH, or CH_3 and n is 1 or 2, and ionic forms thereof.

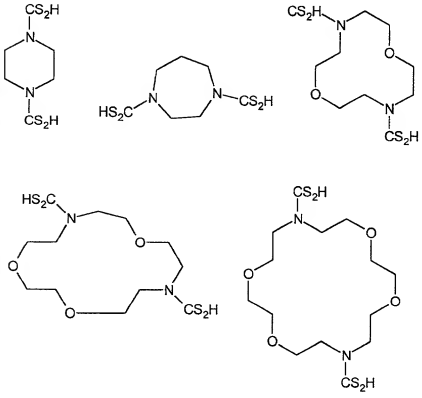
11. A multifunctional linker molecule according to claim 10, characterized in that CON_1 and CON_2 independently of each other comprise branched molecular structures.

12. A multifunctional linker molecule which is selected from the group comprising 1,4-dimercaptoacetamidobenzene of the general formula



in which $R_{1,2}$ is independently selected from CH_3 and/or Cl, 1,4-dimercaptoacetamidocyclohexane, 1,4-dimercaptoacetamido-9,10-anthraquinone, 1,5-dimercaptoacetamido-9,10-anthraquinone, 1,8-dimercaptoacetamidooctane, 1,4-dithiocarbamatobenzene and 1,4-dithiocarbamatocyclohexane.

13. Multifunctional linker molecule selected from the group comprising



14. 1-, 2-, or 3-dimensional assembly of nanostructured units comprising a multifunctional linker according to any of claims 1 to 13, wherein the conductivity of the assembly is determined by the structure of the multifunctional linker.

15. Assembly according to claim 14, characterized in that the nanostructured units are selected from the group comprising nanoparticles, like metal, semiconductor, or core/shell semiconductor nanoparticles, nanowires, nanotubes, nanobelts, and electrodes.

16. Assembly according to claim 14 or 15 in the form of a thin film of interconnected nanostructured units.

17. Use of an assembly according to any of claims 14 to 16 as self-assembled electronic circuit elements, electrodes, and metal coatings.